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Engineering Systems Thinking: Definition, Assessing and Correlation with Project Success

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Outline

Engineering Systems Thinking:

- Definition
- Assessing
- Correlation with Project Success

Engineering Systems Thinking: Definition

Engineering Systems Thinking

- *Systems thinking'* is a discipline for seeing wholes (Senge, 1994).
- *Engineering Systems Thinking* is a major high-order thinking skill that enables individuals to successfully perform systems engineering tasks.
- To successfully perform systems engineering roles, systems engineers need a systems view or a high **C**apacity for **E**ngineering **S**ystems **T**hinking (CEST).
- It was found that this ability is a consistent personality trait, and that it can be used to distinguish between individual engineers.

Engineering Systems Thinking: Assessing

Assessing Systems Thinking in Engineers

Assessing CEST (Capacity for Engineering Systems Thinking)

- Frank (2010) introduces an interest inventory for assessing engineers' interest regarding systems engineering positions and the results of three studies aimed at examining its reliability and validity.

- The will and the interest to be a systems engineer mainly means the will and interest to deal with positions that require a capacity for engineering systems thinking (CEST).

- Interest inventory is a very common tool which is frequently used to help people choose a profession, and as a selection tool (to determine whether a certain individual is suitable for a certain role) in the recruiting process.

Assessing Systems Thinking in Engineers (Cont.)

Assessing CEST (Capacity for Engineering Systems Thinking)

- The content validity of the interest inventory was achieved by basing its items on the findings of a prior study aimed at identifying the characteristics of successful systems engineers (Frank, 2006).

- Thirty-one competencies of successful systems engineers were found in this prior study and they were classified into ten cognitive characteristics, eleven abilities, ten individual traits and three dealing with multidisciplinary knowledge and experience.

Engineering Systems Thinking: Correlation with Project Success

Introduction: The Problem

- According to the Standish Group Report (2009), **68%** of all projects failed:
  - 44% of the projects were late, over planned budget, and/or had less than the required features and functions.
  - 24 % were cancelled prior to completion or delivered and never used.
- What causes projects to fail? Many reasons can been found in the literature.
- We focus here on one reason – lack of engineers with a high capacity for engineering systems thinking (CEST).

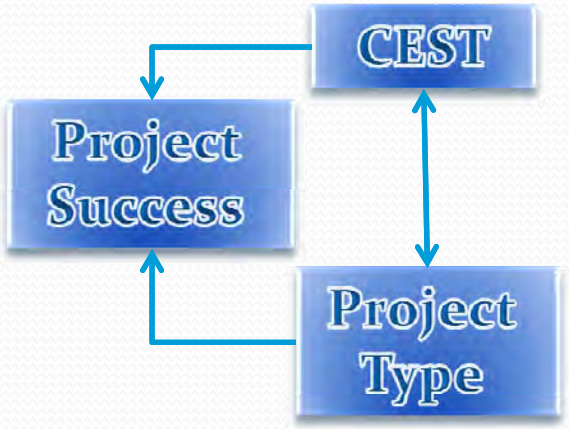
The Goal of the Study

The study aimed at exploring the relationship between (1) systems engineers' capacity for engineering systems thinking (CEST), (2) project types and (3) project success.

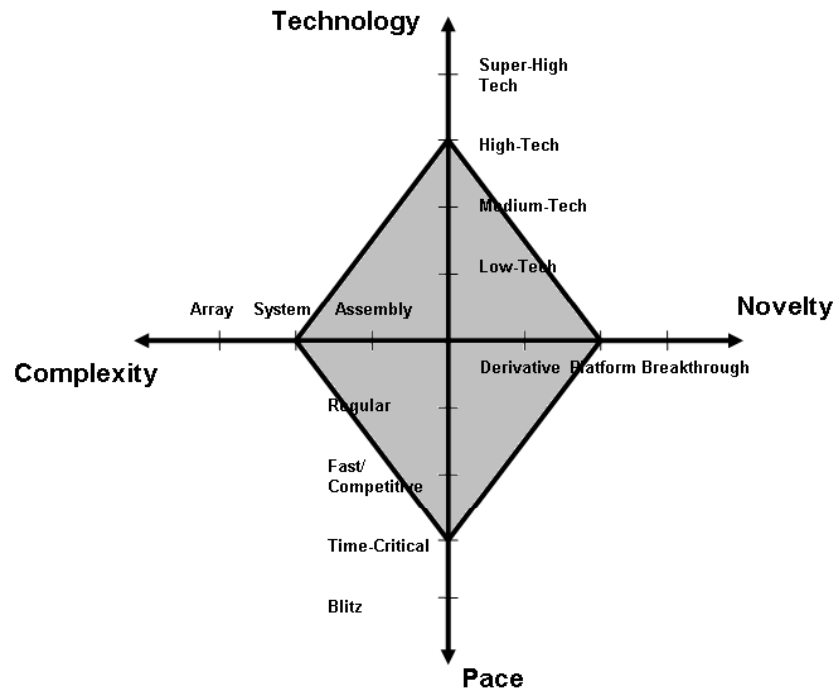
We have already defined CEST (slide 4).

Let us now explain what do we mean by:

- Project types
- Project success



Project Types



- One of the common misconceptions is that similar tools can be used for all projects.
- Shenhar and Dvir (2007) identified four dimensions to distinguish among projects: **N**ovelty, **T**echnology/uncertainty, **C**omplexity, **P**ace (NTCP model).
- NTCP model can guide project managers and systems engineers in selecting their project handling style.

Project Success

- The literature traditionally use time, budget, and performance as the main indicators of project success.
- More elements to the assessment of project success found such as:
  - Stakeholders' satisfaction.
  - Efficiency of the implementation process.
  - Personal growth.
  - Business and financial performance.
  - The creation of new opportunities.
  - (and many more …).

Method: The Tool

A self report questionnaire comprised of three parts :

- Assessing CEST
  - This tool developed by Frank (2010) – slides 6 and 7.
- Assessing project success
  - Measured along 5 dimensions: Meeting planning goals (project efficiency), customer benefits (success from the customer's point of view), benefits to the developing organization, benefit to the community and national infrastructure, benefit to the project team.
- Identifying project type
  - The items in this part were based on the NTCP model.

Method: The Participants

- ***Population*** **-** all senior systems engineers employed in the 'high-tech – electronics – systems' industry in Israel (including
- ***Sampling frame*** **-** all senior systems engineers employed in the sixteen largest 'high-tech – electronics – systems' companies in Israel.
- ***Sample*** – 114 senior systems engineers who were randomly selected from the sampling frame (sampling error 9.18%, $p \leq 0.05$).
  - About 40% of the survey's participants were from the defense industry.

Method: The Projects

The projects can be classified, according to the NTCP model, as follows:

- **Novelty**: 54 subjects were engaged in 'platform' projects, 30 in 'derivative' projects and 30 in 'breakthrough' projects.
- **Technology**: 11 subjects were engaged in 'super-high-tech' projects, 65 in 'high-tech' projects, 26 in 'medium-tech' projects and 12 in 'low-tech' projects.
- **Complexity**: 44 subjects were engaged in 'array' projects, 60 in 'system' projects and 10 in 'assembly' projects.
- **Pace:** 3 subjects were engaged in 'blitz' projects, 23 in 'time-critical' projects, 41 in 'fast-competitive' projects and 47 in 'regular' projects.

- The duration of the projects: 6 months – 3 years.
- The budget: $200K – 200M (average – $28.7M).

Method: The Procedure

Two stages:

- Pilot survey - 36 senior systems engineers participated.
- Main survey.

- The findings of the pilot study were used to revise and improve the questionnaire.
- Confidentiality at all stages was promised and enforced.

Main Results (slide 1 of 5)
CEST Scores

CEST Group	Mean	N	Std. Deviation
1 (Low CEST)	46.94	9	9.745
2 (Medium CEST)	72.28	45	4.909
3 (High CEST	84.67	60	5.094
Total	76.80	114	11.902

Main Results (slide 2 of 5)

Correlations between the subjects‘ CEST and the projects' five success criteria

	Efficiency	Custor	Team	Business	Future	PR_Succ
Pearson Correlation	**.249(**)**	.065	.050	**.338(**)**	**.305(**)**	**.310(**)**
Sig. (2-tailed)	.008	.503	.601	.000	.001	.001
N	114	109	114	105	114	114

The findings indicate that there is a ***positive significant correlation*** between subjects' CEST and project success in four dimensions

Main Results (Slide 3 of 5)

- An ANOVA test was performed to examine whether the project type (according to the NTCP model) is a moderator variable that affects the correlation between the subjects' CEST and project success.
- It was found that the project type does not significantly affect the correlation between the subjects' CEST and project success.
- However, in order to test whether there is a specific dimension (novelty, technology, complexity and pace) that affects the correlation between the subjects' CEST and project success, four additional two-way ANOVA tests were performed – one test for each dimension.

Main Results (Slide 4 of 5)

- It was found that the variable 'novelty' does significantly affect the correlation between the subjects' CEST and project success.
- Post-Hoc tests revealed that the more innovative the project, the higher the correlation between the subjects' CEST and project success.
- In other words, successful systems engineers (systems engineers with high CEST) are needed most in platform projects (projects that produce a new generation of products) and breakthrough projects (radical innovative projects).

Main Results (slide 5 of 5)

- No significant correlation was found between CEST and the satisfaction level of the projects' teams.
- No significant correlation was found between CEST and the satisfaction level of the customer and end-users.
- Organizations that pursue customer satisfaction should nominate projects managers who are committed to success in these measures.

Conclusions (slide 1 of 4)

- The findings of this study clearly show that there is a significant correlation between CEST and project success.
- The extent of the project's novelty (derivative, platform or breakthrough) is a moderator variable that affects this correlation.
- The more innovative the project is, the higher the correlation between the subjects' CEST and project success.
- Successful systems engineers (systems engineers with high CEST) are needed most in platform projects (projects that produce a new generation of products) and breakthrough projects (radical innovative projects).

Conclusions (slide 2 of 4)

- However, the findings of the current study show that the coefficient of determination, R^2, is relatively low.
- This means that the prediction of project success can be only minimally based on CEST.
- Only a low percent of the variation in project success can be explained by CEST. The remaining percentage should be explained by other variables.
- Of course, this finding makes sense, as many other variables might explain project success,

Conclusions (slide 3 of 4)

- In any case, a significant correlation between CEST and project success does exist.
- Because correlation is *necessary* for causation, it is clear beyond all doubt that organizations should select engineers who possess a high capacity for engineering systems thinking.
- Organizations also should create a supportive environment for enabling systems thinking development in engineers.
- But, what are the best ways to create such a supportive environment? Is the engineering systems thinking capability acquired or innate?

Conclusions (slide 4 of 4)

- Previous studies show that CEST can be developed through experience and learning.
- Therefore, organizations should create a supportive environment for enabling systems thinking development in engineers and managers.
- Engineers and managers with a high CEST may lead to better performance in general, and especially in regard to meeting design goals and overall project success.

Any questions?

THANK YOU

Thank You!